

2014-2015 California Measles Outbreak: It's a Small World After All

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NVAC Meeting
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Risk of Imported Measles is Ongoing

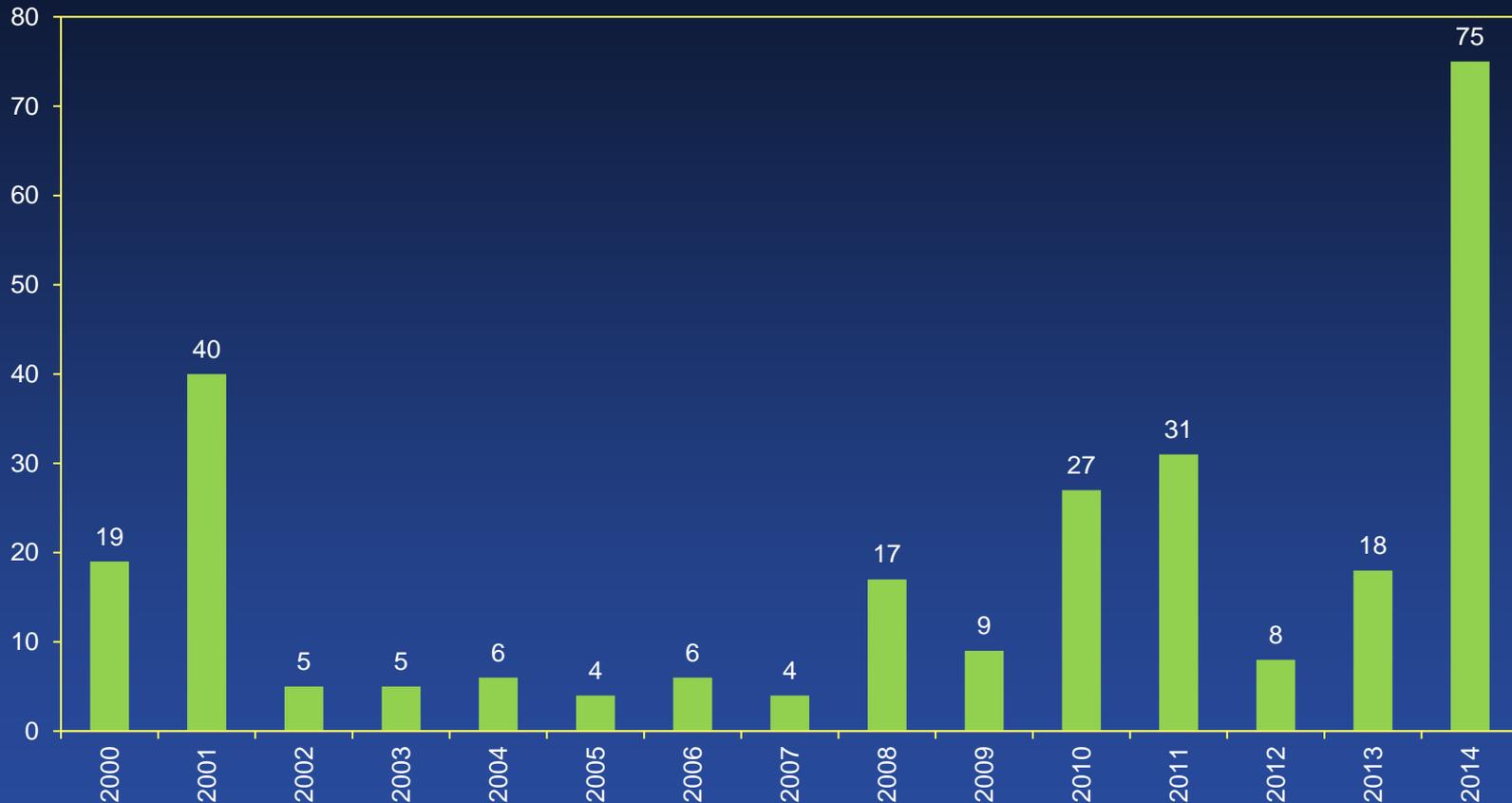
- Since measles is still endemic in all countries outside of North and South America, the U.S. is at continued risk of imported measles cases from foreign tourists to the U.S. and U.S. travelers returning from abroad
- In 2014, there were 30 million travelers to the U.S. from countries other than Canada or Mexico; 7 million of these travelers visited California
- In 2014, 30 million U.S. citizens traveled outside of the U.S., Canada or Mexico

Data Sources:

<http://industry.visitcalifornia.com/find-research/california-statistics-trends/>

<http://travel.trade.gov/view/m-2014-O-001/index.html>

Confirmed Measles Cases, California 2000 - 2014



- Since measles was declared eliminated from the U.S. in 2000, the number of measles cases in California has varied by year depending on what is happening in the rest of the world and where cases are imported into California.

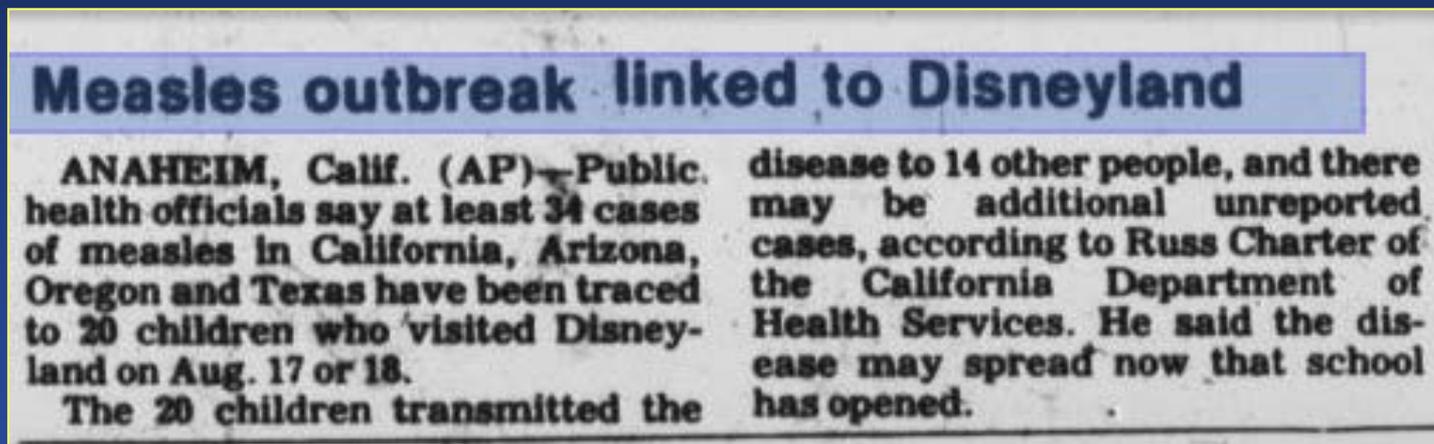


Identifying the Disneyland Outbreak

- Saturday, January 3: CDPH received call about a suspect measles case in an unvaccinated 11 year old whose only recent travel was to Disneyland
- Monday, January 5: six additional suspect measles were reported; two from Utah and four additional suspect cases in California – all of whom had history of travel to Disneyland or California Adventure Park during their exposure period; CDPH alerted CDC and all 61 California local health jurisdictions
- Wednesday, January 7: 7 measles cases had been confirmed and CDPH alerted other states via Epi-X, issued press release, and a provider alert

Background: Measles Associated with a Theme Park

- Disneyland and the adjacent California Adventure Park have over 24 million visitors annually, many from international destinations where measles is endemic
- This is not the first time Disneyland has been implicated as an exposure venue for measles. Report from 1982:



- In addition to foreign travel or contact with foreign visitors, CDPH recommends that providers ask about visits to international venues in the U.S. (airports, theme parks, etc.) when assessing patients with febrile rash illness

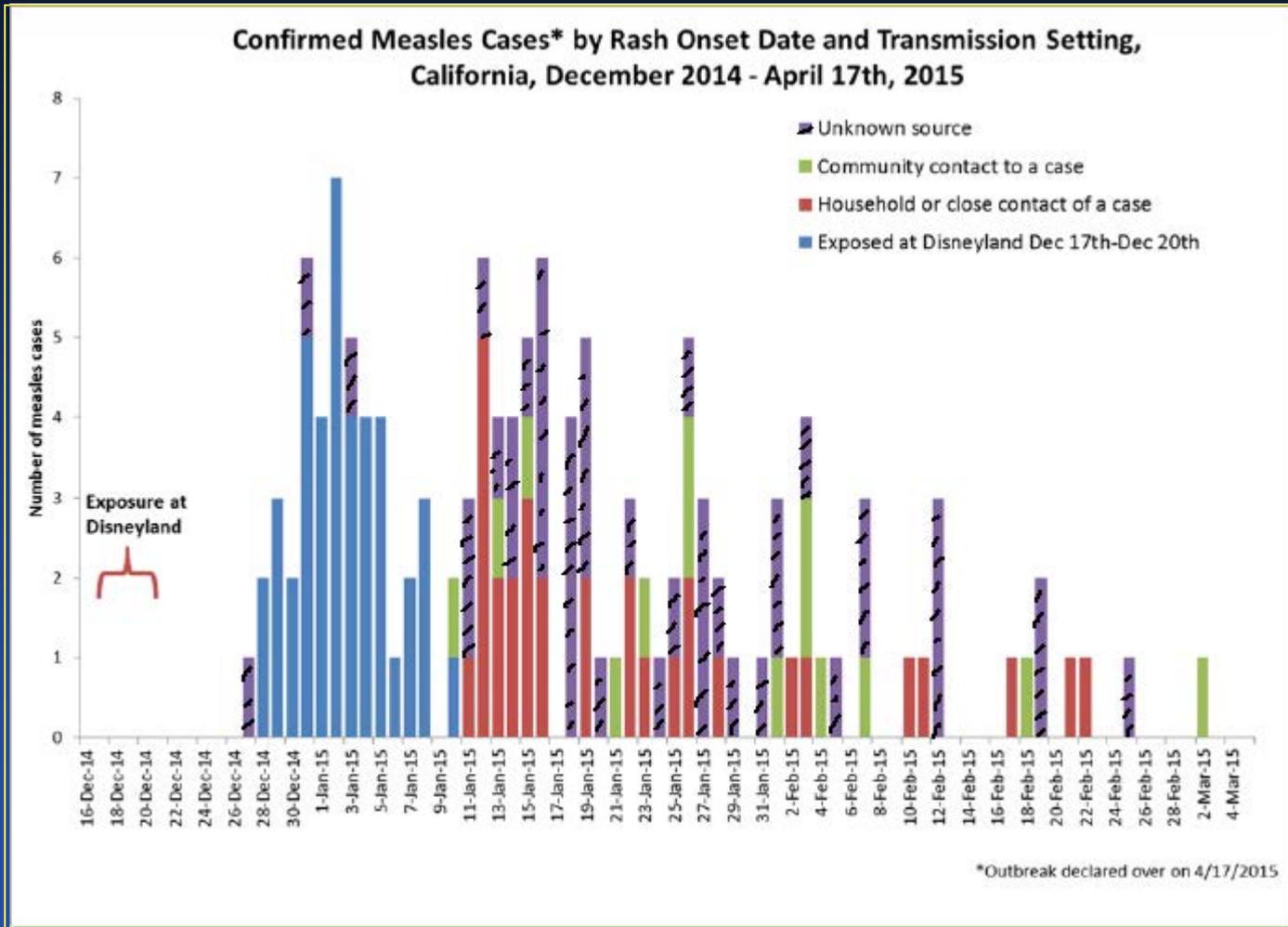
Recommended Control Measures

- Prompt identification and isolation of cases
- Prompt identification of contacts and assessment of their immune status to measles
 - In doing so, in addition to CDC presumptions of immunity (birth <1957, documentation of 2 doses of measles-containing vaccine or serologic evidence of immunity) CDPH has additional immunity criteria unless the contact is known to be unvaccinated:
 - ✓ Having served in the U.S. armed forces; or
 - ✓ Born in the U.S. in ≥ 1970 and attended a U.S. elementary school; or
 - ✓ Entered the U.S. ≥ 1996 with an immigrant visa or have a green card
- Postexposure prophylaxis for high-risk susceptible persons
 - MMR vaccine if <72 hours of exposure
 - IGIM for those <66 pounds ≤ 6 days of exposure
 - IGIV for pregnant women/severely immunocompromised ≤ 6 days
- Quarantine of susceptible persons who did not receive timely postexposure prophylaxis

Recommendations for Measles Testing

- CDPH recommends PCR as primary diagnostic tool for measles; the state lab and 17 local public health labs offer measles PCR testing – benefits of PCR include:
 - Virus can be detected from day of rash onset in respiratory (throat swab preferred) specimens ($\leq 7+$ days after rash) or urine ($\leq 10+$ days after rash)
 - These specimens are easy to collect and are non-invasive
 - The test is rapid (TAT < 1 day) and high throughput
 - Additional testing to identify genotype can be performed
 - More sensitive and specific than IgM testing
 - ✓ IgM testing can yield false positives (rheumatoid factor, pregnancy, etc.)
 - ✓ IgM negative result in blood collected < 72 hours of rash onset cannot be relied upon
 - ✓ IgM testing can be falsely negative in previously vaccinated persons
- During the outbreak, the state lab performed > 1500 PCR tests; local public health labs performed > 900 PCR tests + IgG testing for immunity
- Genotyping was also performed
 - **73 specimens were genotype B3 (outbreak strain)**
 - ✓ 1 genotype D4
 - ✓ 2 genotype D8
 - ✓ 2 genotype H1 } Not counted as outbreak cases
 - ✓ 31 genotype A (vaccine strain) from recently vaccinated persons with febrile rash illness

Confirmed Measles Outbreak Case Rash Onsets – California, December 27, 2014 – April 17th, 2015, n=131



AZ 7
 UT 3
 NE 2
 WA 2
 CO 1
 OR 1
 14

Mexico 1
 Canada 159
 (from single case in child who was infected at Disneyland and returned to a susceptible religious community near Montreal)

California Measles Outbreak

Cases by Exposure Setting

- 42 (32%) of the 131 cases were exposed at Disneyland during December 17-20, 2014, a very high reproduction number for one infectious person (measles $R_0 = 12-18$)
- 31 (24%) cases were household or other close contacts (e.g., boyfriend/girlfriend) of cases
- 11 (8%) cases were exposed in a healthcare setting; three were healthcare personnel (HCP) exposed at work
 - Emergency department: 7
 - Urgent care: 3
 - Hospital inpatient unit: 1
- 3 (2%) were exposed in a mall
- 44 (34%) had unknown exposure setting

Vaccination Status of Measles Outbreak Cases

- 82 (62%) cases had immunization status verified
 - 57 (70%) of these were unvaccinated
 - ✓ 28 (49%) personal beliefs exemptions
 - ✓ 16 (28%) too young
 - ✓ 2 (4%) missed dose/alternative schedule
 - ✓ 11 (19%) unknown reasons
 - Of the 25 (31%) who were vaccinated:
 - ✓ 10 (12%) had one dose of MMR vaccine
 - ✓ 13 (16%) had two doses of MMR vaccine
 - ✓ 2 (2%) had three doses of MMR vaccine
- 49 (38%) of the 131 cases did not have immunization records; 48 of these were adults - 20 of whom self-reported being vaccinated; many others were unsure

Age Distribution and Hospitalization Status of California Measles Outbreak Cases

Age (years)	Total	Incidence per 100,000	
		population*	Percent
<1	14	2.67	11%
1-4	21	1.05	16%
5-19	24	0.31	18%
20-29	30	0.54	23%
30-39	21	0.40	16%
40-49	10	0.19	8%
50-59	9	0.18	7%
60-69	1	0.03	1%
70+	1	0.03	1%

*Population denominator data from the Department of Finance have been standardized with 2010 Census data

Accessible Version of table on Page 47

- Majority of cases were adults
- Highest incidence was among infants <1 year of age
- 20% hospitalized - lower % than in recent years (~25%)



Vignettes of Severe Measles Cases

- An adult collapsed at home and was admitted due to severe pneumonia
 - Intubated and ventilated
 - Multiple organ injury; renal dialysis
 - Minimally responsive during much of hospital stay
 - Extubated during the third week of hospitalization
 - Required physical and occupational therapy
 - Discharged home after four weeks – still on oxygen and using a wheel chair for mobility; required long period of convalescence
- An adult on high dose steroids was admitted with bilateral pneumonia and subsequently diagnosed with measles
 - Developed acute respiratory distress syndrome and was intubated
 - Remained in respiratory failure for several days and was treated with IV ribavirin on an IND protocol
 - Discharged at day 15 into a rehabilitation program; required a long period of convalescence at home

Successes

- Prompt identification of the outbreak and notification of local health jurisdictions and providers
- Excellent and tireless work by local health jurisdictions in case and contact investigations
- Lab capacity at state and local labs enabled quick TAT
- Prior experience with measles; many materials already developed for local health departments and providers
- Statewide calls with local health departments; everyone on same page, using same protocols
- Communication with providers on measles identification, infection control and reporting
- Regular communication with the public on the status of the outbreak – transparent, including vaccine failures
- Outbreak contained within two months with no more than three generations of transmission

Examples of Local Health Jurisdiction and Provider Materials



California Department of Public Health – March 2015

Measles Investigation Quicksheet



Measles infectious period

From four days before rash onset through four days after rash onset (day of rash onset is day 0).

Measles exposure

Sharing the same airspace with a person infectious with measles (during the 4 days prior through the 4 days after their rash onset), e.g., same classroom, home, clinic waiting room, airplane etc., or were in these areas up to 1 hour after the infectious person was present. Although CDC recommends using a 2 hour window, there is only one report in the literature of measles transmission >60 minutes after an infectious person has left the setting.

No minimum time period has been established for exposure, but it is presumed that longer exposures are more likely to result in measles transmission than brief, transient exposures.

When exposures have occurred in venues in which it is not possible to identify individuals, it is helpful to notify local health care providers so that they can be on the alert for possible cases. In addition, some local health jurisdictions issue press releases to notify the public.

Measles incubation period

The period from exposure to onset of prodrome is generally 8–12 days. In family studies, the average interval between the appearance of rash in the index case and in subsequent cases is 14 days (range 7–21 days).

Measles clinical case definition

- A generalized rash lasting ≥ 3 days; and
- a temperature $\geq 101^\circ\text{F}$ ($\geq 38.3^\circ\text{C}$); and
- cough, coryza, or conjunctivitis.

Measles laboratory criteria for diagnosis

- **Preferred:** Detection of viral RNA by reverse transcription polymerase chain reaction (RT-PCR); or
- **Acceptable:** Serum* measles IgM antibody positive
- **Acceptable:** Isolation of measles virus; or
- **Acceptable:** Significant rise in serum* measles IgG antibody between acute and convalescent titers.

*Capillary blood (finger or heel stick) can be used for serology if venous blood cannot be obtained.

Please send specimens to a public health lab; use of commercial labs may delay testing.

More information on testing, including capillary blood collection, is available at: <http://www.cdph.ca.gov/HealthInfo/discond/Documents/CDPHMeaslesLabTesting2011-01.pdf>

Case classification

- **Suspected:** Any febrile rash illness.
- **Probable:** A case that meets the clinical case definition, has non-contributory or no serologic or virologic testing, and is not epidemiologically-linked to a confirmed case.
- **Confirmed:** A case that is laboratory-confirmed, or a case that meets the clinical case definition and is epidemiologically-linked to a confirmed case. A laboratory-confirmed case does not need to meet the clinical case definition.

Immunity to measles

Non high-risk people† can be presumed to be immune to measles for the purposes of measles case investigations if they:

- were born prior to 1957; or
- have written documentation with dates of receipt of at least one dose of measles-containing vaccine given on or after their first birthday in 1968 or later; or
- have documented IgG+ test for measles; or
- have a history of physician diagnosed measles; or
- served in the U.S. armed forces; or
- were born in U.S. in 1970 or later and attended a U.S. elementary school; † or
- entered the U.S. in 1996 or later with an immigrant visa or have a green card. ‡

†Additional evidence of immunity is required for exposed high-risk persons, e.g., healthcare personnel of any age, pregnant women, immunocompromised people, household contacts of a case, or persons in settings with known unvaccinated persons (e.g., childcare settings). Additional evidence of immunity may also be required during an outbreak. Immunity can be presumed if the exposed person:

- has documentation of a positive measles IgG test; or
- has documentation of two doses of measles vaccine given in 1968 or later, separated by at least 28 days, with the first dose on or after the first birthday

‡Unless known to be unvaccinated for measles, e.g., having a medical contraindication to vaccination or being philosophically or religiously opposed to vaccinations.

California Department of Public Health
HEALTH ADVISORY – February 20, 2015

Measles Update: 123 Confirmed Measles Cases in the State of California Continue to Look for Signs of this Highly Contagious Disease in Patients

As of February 20, measles had been confirmed in 123 California residents since the end of 2014. At this time, case numbers are being updated every Monday, Wednesday and Friday and reports are available at: <http://www.cdph.ca.gov/HealthInfo/discond/Pages/MeaslesSurveillanceUpdates.aspx>

To prevent additional measles cases, California healthcare providers are recommended to:

Remember the diagnosis

The recent measles cases in California highlight the need for healthcare professionals to be vigilant about measles. *Your expert eye, diagnostic skills, and prompt reporting of suspect measles patients to public health can make a difference in stopping the spread of this highly contagious disease in your community.*

Key Points

- Consider measles in patients of any age who have **a fever AND a rash** regardless of their travel history.
- In measles cases there **must be some fever**, even subjective fever, and the **rash must start on the head or neck**.
- Patients with measles usually have at least 1 or 2 of the “3 Cs” – **cough, coryza and conjunctivitis**.
- If measles testing is being considered, **please contact your local health department immediately**. Your local health department is your partner and will assist you.

Isolate patients with acute febrile rash illnesses

Patients with rash and fever may have measles or other communicable diseases that can be transmitted to other patients. It is prudent to isolate such patients until measles or other diseases such as varicella have been ruled out (see isolation instructions on page 3). If measles is suspected, alert your local health department as soon as possible. The risk of measles transmission to others can be reduced if control measures are implemented immediately. Contact information for all local health departments in California can be accessed at: <http://www.cdph.ca.gov/services/Pages/LocalServices.aspx>

Questions to ask patients with febrile rash illness

- **Fever assessment:**
 - When did the fever start? (fever should precede rash)
 - How high has the fever been without the use of antipyretics (or is the fever subjective)?
 - Did the fever persist, or did it disappear? (if fever disappeared before rash onset without the use of antipyretics, the patient is unlikely to have measles)
 - Fever generally peaks on day 2 or 3 after rash onset; fever persisting longer than this in a confirmed measles case is an indication of a complication.



Challenges

- Provider awareness of symptoms and risk factors for exposure
 - The first three cases were originally diagnosed with Kawasaki Disease
- How to prioritize large contact investigations in the setting of an outbreak in which one case may have hundreds of contacts
 - Surge capacity at state and local health departments was strained
 - Where an exposure takes place makes a difference - may not be able to directly contact all exposed persons
- Inability to rapidly determine immune status of exposed people; IgG immunity testing takes time and resources
 - Robust immunization registry, including adults, is needed
 - Routine provider assessment of the immune status of adults
 - Although required by the CalOSHA Aerosol-Transmissible Diseases Standard, many exposed HCP had no record of measles immunity assessment
- Two dose MMR recipients and IgG+ people can and did develop measles

Satellite Testing Site in Orange County

- 35 (27%) of cases occurred in Orange County where Disneyland is located
- Outdoor clinic under canopy
 - One medical assistant
 - One office technician
- Testing
 - Suspect cases who had already been assessed by a healthcare provider
 - Exposed persons
- Tests performed
 - Throat swab PCR
 - Serum IgM, IgG



Challenges, continued

- Determining which exposed “immunocompromised” people needed IVIG; ACIP guidance on this topic is insufficient, treatment expensive and timeliness critical
- In the setting of an outbreak, febrile rash illnesses in recently vaccinated persons can’t be assumed due to MMR
 - Vaccine reactions can be clinically compatible with measles
 - Need rapid genotyping test (current test not timely enough to be of use for postexposure prophylaxis decisions)
- Need additional capacity for measles PCR testing
 - Large numbers of patients tested from all regions of state
 - Getting results quickly is critical for public health decisions
 - Testing logistics can be complicated (shipping, receiving, communication of results, etc.)
- Large NICU exposure, which raised complicated questions

Questions about Measles Contact Investigations

- How to best balance resources used for contact investigations with the possibility of additional measles cases in a setting of high population immunity?
- Better understanding of what factors enhance measles transmission?
 - Are infants less likely to transmit measles than older persons (as in TB)?
 - Are there “super spreaders” and can be they identified early?
 - Are some types of exposures more likely to lead to transmission than others, e.g., host and venue factors?
 - Are some genotypes more transmissible than others?
 - Are cases who have had 1-2 doses of MMR or are IgG+ and have less severe illness, less infectious (waning immunity vs. primary failure)?
- Is there waning measles immunity among U.S. adults (lack of boosting); should all adults receive 2 doses of MMR vaccine?
- How effective is postexposure prophylaxis? (no recent studies)

Most Important Question

- How to best balance resources used for contact investigations with the possibility of additional measles cases in a setting of high population immunity?
 - We can only identify contacts in some settings
 - ✓ Does it make sense to do such intense follow-up of identified contacts while others have no follow-up?
 - ✓ Do all identified non high-risk contacts need to be contacted by telephone? Is sending a letter sufficient?
 - ✓ What is the risk of missing high-risk people?
 - Can more assumptions of immunity be made for identified contacts?
 - ✓ Can U.S. adults be assumed immune unless they know they aren't
 - ✓ How to continue ensuring immunity among high risk people
 - For unidentified contacts – are public notices of value?

Costs of Measles Investigations*

- 2008 – San Diego CA outbreak with 12 cases, including one hospitalization, and 839 exposed persons
 - Public health cost of each case each was \$10,376, including 1,745 person hours on investigation and containment efforts
 - Direct medical costs for cases and exposed infants were \$16,163 (\$14,458 for hospitalized child)
 - Family expenses for quarantine of 48 children were \$775/child
- 2008 – Tucson AZ outbreak with 14 cases
 - 2 hospitals spent \$799,136 responding to 7 healthcare-associated cases; 56% of the cost was due to furloughs of HCP due to lack of evidence of immunity
- 2011 – 16 measles outbreaks in the U.S. with 107 total cases
 - Estimated public health costs ranged from \$2.7-\$5.3 million
 - Estimated total contacts ranged from 8,936-17,450
 - Estimated total public health hours ranged from 42,635-83,133 – equivalent to full time work for 20-39 staff for a year
 - Each public health department incurred costs of \$11,933-\$29,833/case
 - Does not include costs to hospitals, clinics, schools, etc.
- 2013 – 1 measles case in ambulatory care clinic
 - Exposure to 53 patients, 60 parents, and 10 employees
 - Overall clinic costs were \$5655

*Sugerman et al. *Pediatrics*. 2010;125(4), Chen et al. *J Infect Dis*. 2011 Jun 1;203(11), Ortega-Sanchez, et al. *Vaccine*. 2014;32, Wendorf et al. *Pediatr Infect Dis J*. 2015;34(6).

Cost of California Measles Outbreak

- Using median cost per measles case developed by CDC's Ortega-Sanchez (referenced in prior slide), the estimated public health cost in California for this outbreak is \$1.56M - \$3.91M dollars, but it's likely much more
- These costs do not include the costs to healthcare facilities participating in contact investigations, lost work or school for cases and quarantined persons and their caregivers, etc.
- Alameda County with 6 cases and >700 contacts estimated that >56 staff spent 3770 hours working on the outbreak resulting in personnel costs of >\$190,000 (thought to be an underestimate)
- Using the ~\$22,000 median cost per hospitalized measles case from 2009-2013, total hospitalization costs for the 21 hospitalized patients are estimated at close to \$500,000 but are likely higher
 - There were no intubated cases in 2009-2013; one 2008 case similar to the two severe 2015 cases described earlier had \$1.18M in hospital costs

Additional Thoughts

- This outbreak captured the attention of the public
 - Outbreak started at Disneyland, “the happiest place on earth” and had all the elements of a good news story
 - People viewed as wealthy and entitled and were seen as the cause of the outbreak and appeared to wake the “sleeping giant” (majority of population who vaccinate their children)
- This outbreak advanced the national conversation about immunization and led to state initiatives to limit or eliminate personal beliefs exemptions to school immunization requirements
- Were any beliefs changed?
 - Anecdotal evidence suggests that it’s unlikely that people with strongly held beliefs changed them as a result of this outbreak
 - Parents who were “on the fence” may have been influenced
 - Need more discussion about “natural immunity” and risk of SSPE

The New York Times

Vaccine Critics Turn Defensive Over Measles

By JACK HEALY and MICHAEL PAULSON JAN. 30, 2015

California's measles outbreak is over, but vaccine fight continues

Parents who oppose measles vaccine hold firm to their beliefs

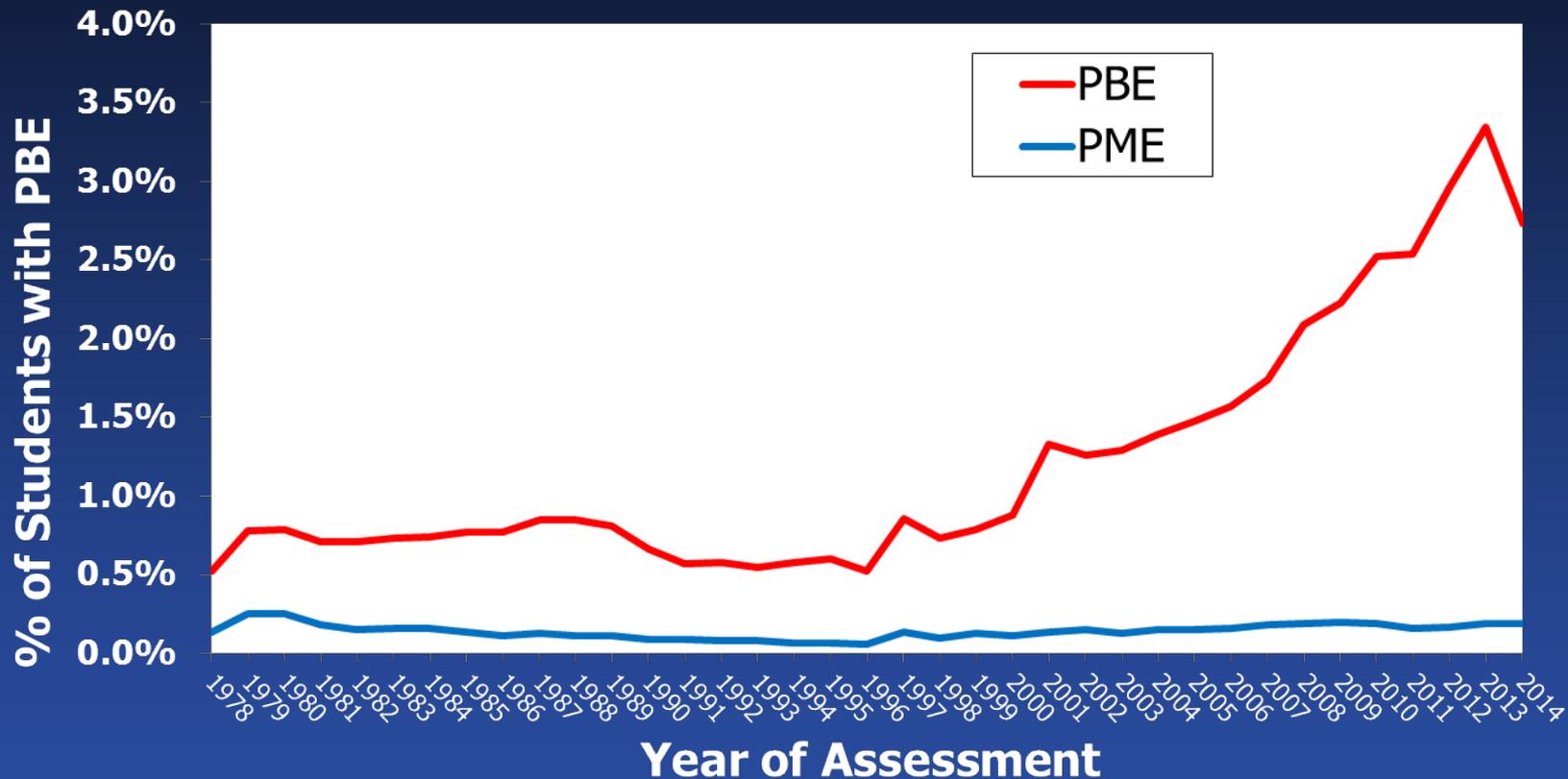


Kelly McMenimen of Marin County, Calif., said she decided not to vaccinate her son Tobias, saying she did not want "so many toxins" entering his body. Jim Wilson/The New York Times

California Immunization Requirements

- Children are required to have two doses of MMR vaccine at kindergarten entry
- Personal beliefs exemptions (PBEs) are permitted
 - Prior to 2014 school year they were easy to obtain and only a parental signature was required
 - Between 2007 and 2013, the number of PBEs doubled
- In fall 2014, a new law went into effect that required parents desiring a PBE for their child to be counseled about vaccines by a healthcare provider
 - For the first time in many years the % of kindergarten children with PBEs went down, not up – from 3.15% to 2.54%
- The California legislature is currently considering a bill to eliminate personal beliefs exemptions

Permanent Medical (PME) and Personal Beliefs (PBE) Exemptions Among Kindergarten Students, California 1978-79 to 2014-15 School Years



Immunization rates for all schools in California are available at:

<https://www.cdph.ca.gov/programs/immunize/Pages/ImmunizationLevels.aspx>

2014 Random Sample of 418 California Kindergarten Students With Missing Doses of Required Vaccines*

MMR vaccine was most frequently missed dose; 20% missing both doses

Missing doses			# of Doses Missing									
			1		2		3		4		5	
Vaccine Series	# Missing required doses	% Missing required doses	#	%	#	%	#	%	#	%	#	%
MMR	284	68%	226	80%	58	20%						
DTaP	255	61%	185	73%	26	10%	11	4%	9	4%	24	9%
Polio	187	45%	140	75%	12	6%	4	2%	31	17%		
Hep B	89	21%	33	37%	11	12%	45	51%				
Varicella	69	17%	69	100%								

*Children who entered kindergarten “conditionally” without all required vaccine doses (4 doses polio, 5 doses DTaP, 2 doses MMR, 3 doses HBV, 1 dose varicella vaccine), not children with Personal Beliefs Exemptions

How does the U.S. rank in measles vaccine coverage among 1 year olds?

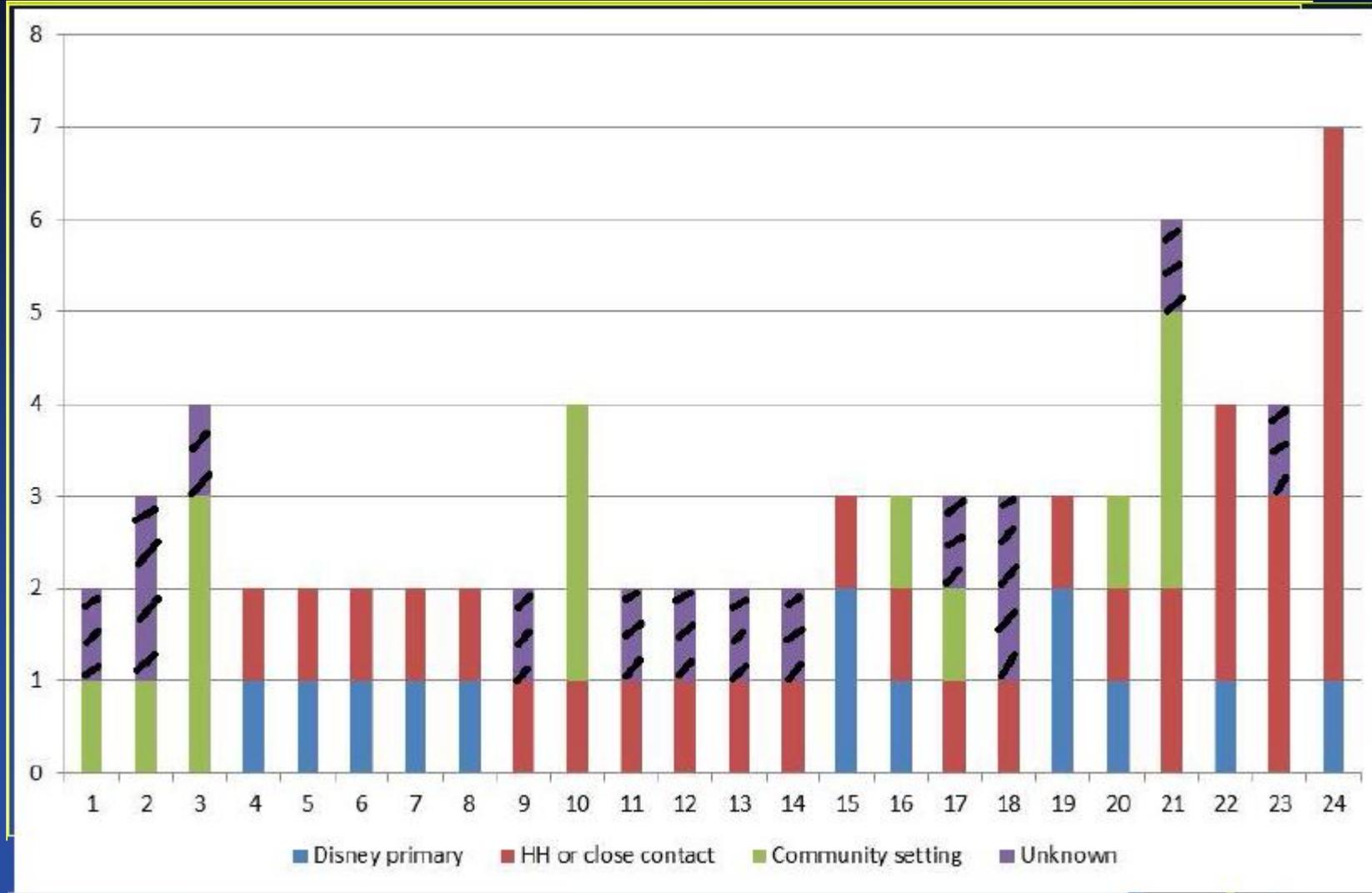
- The U.S. ranks 114th among 194 countries with 91% coverage
- Among 27 EU countries plus Iceland and Norway – 15 countries do not have any mandatory vaccinations; 14 have at least one mandatory vaccination
 - 8 Eastern European countries mandate MMR vaccine
 - Canada has no school immunization requirements (95% measles vaccine coverage among 1 year olds)

http://gamapserver.who.int/gho/interactive_charts/immunization/mcv/atlas.html
<http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=20183>

Acknowledgements

- CDPH Immunization Branch
- CDPH Viral and Rickettsial Disease Laboratory
- California Local Health Jurisdictions
- Centers for Disease Control and Prevention

Measles Transmission in Clusters with ≥ 2 Cases



Measles Clusters, cont.

- 24 clusters (possibly more as we receive more complete data)
- 21/24 clusters have transmission between household or close contacts
- 7/24 clusters involved healthcare settings
 - 11 cases associated with healthcare settings so some healthcare exposures resulted in >1 transmission event

Measles Symptoms by Immunization Status - Orange County, 2014-2015

	Not vaccinated (n=20)	Vaccinated/serologic proof of immunity (n=10)	Unknown vaccination status (n=27)
Fever	100%	80%	92%
Cough	83%	50%	73%
Coryza	89%	55%	62%
Koplik spots	38%	25%	0%
Conjunctivitis	72%	33%	42%
Diarrhea	11%	30%	8%
Rash duration	6 days (4-8d)	4.5 days (4-6d)	5 days (2-9d)
Hospitalized	20%	20%	19%
LOS	3-4 d	2-5 d	1-6 d
Otitis	11%	0%	4%

Recent Measles Cases Among Healthcare Personnel

- Nine measles cases reported in healthcare personnel (HCP) in 2014 and 2015 (including, but not limited to, Disneyland outbreak cases)
- Exposures include:
 - Six HCP who provided direct patient care or had face to face contact with a patient infectious with measles
 - The remaining had no contact (1), unknown if there was contact (1), entered a room that a measles case had been in (1)
- Vaccination status:
 - Appropriate vaccination (4), IgG positivity (2), unknown status (3)

2014 and 2015 Measles Cases Among Healthcare Personnel*

- Case #1: Provided patient care and had documentation of two MMR; PCR positive
- Case #2, Provided patient care and had been documented as >2 MMR and IgG positive prior to exposure
- Case #3 Provided patient care, IgG positive
- Case #4 Provided patient care, IgG positive
- Case #5 Provided patient care, 2 MMR doses
- Case #6 Face to face contact, unknown vaccination status
- Case #7 Works in ED but no direct patient contact, 2MMR
- Case #8 Works in ED, unknown if patient contact, unknown vaccination status
- Case #9 Works on hospital floor, was in patient room after patient had left; unknown vaccination status but found to be IgG negative during the contact investigation

* Including non outbreak related cases



Lessons Learned from Investigating Healthcare Exposures

- Rapid identification and isolation of measles cases very important
- HCP should have evidence of measles immunity, even those born <1957 should be tested if exposed
 - It is not recommended to test for measles IgG in personnel with two documented MMR
- HCP who have been exposed to measles should self-monitor for symptoms even if they have acceptable evidence of immunity
 - Symptoms may be modified in persons with a history of vaccination
- HCP providing direct patient care with a measles case should wear an N95 respirator regardless of whether they have acceptable evidence of measles immunity

Healthcare Workers with Measles - Clinical and Epidemiologic Features, 2014

Measles Immunity Prior to Exposure	Exposure	Illness Onset	Fever	Cough	Coryza	Rash	Days considered infectious while asymptomatic	Days working during active symptoms	Number of patients exposed
IgG ⁺	3/3/2014	3/17/2014	Y	Y	N	3/18/14	3	0	0
IgG ⁺	3/3/2014	3/14/2014	Y	N	N	3/18/14	0	4	850
2 MMR	3/7/2014	3/18/2014	Y	N	N	3/20/14	2	2	26
4 MMR IgG ⁺	3/7/2014	3/16/2014	N	Y	N	3/20/14	0	4	72
Unknown vaccine history, IgG equivocal	3/7/2014	3/19/2014	Y	Y	Y	3/21/14	2	0	0

Orange County Healthcare Facility Transmission, 2014 and 2015

- 57 cases
- 56 healthcare facility exposure events
- >3000 patients and staff exposed
- 10 transmissions in healthcare facilities
 - 7 infected healthcare workers
 - ✓ 1 additional healthcare worker developed disease - likely patient exposure, though no source identified
 - 3 infected patients
 - ✓ 9 month old
 - ✓ 18 year old with history of two MMRs
 - ✓ 19 year old with unknown immunization history

Orange County Healthcare Facility Exposures, 2014-2015

- Of 10 healthcare facility transmissions:
 - 5 of 7 healthcare worker cases had a history of face-to-face exposure to a patient with measles
 - ✓ 1 was healthcare worker who denied face-to-face exposure to patient
 - ✓ 1 was housekeeping worker who cleaned room after patient left
 - 2 were patients in same waiting room at same time as cases

Four Orange County School Measles Exposures, 2015

- One preschool, one grade school, one high school, one high school entrance test
- Student immunization rates over 98% in all facilities
- All students without proof of at least one dose of MMR were excluded from days 7-21 after exposure
 - Orange County tried to define which students were at risk, but this was frequently problematic
- 37 students were excluded
- No secondary cases

School Exposures: Staff

- Most staff did not know their immunization status
- For a large school, hundreds of staff will be potentially exposed
- Must work with school to identify staff most likely to have been exposed, eg, teacher in classroom with case, etc.
- Orange County conducted clinics at the school to test staff who were exposed
- All staff tested proved to be immune

Summary Points

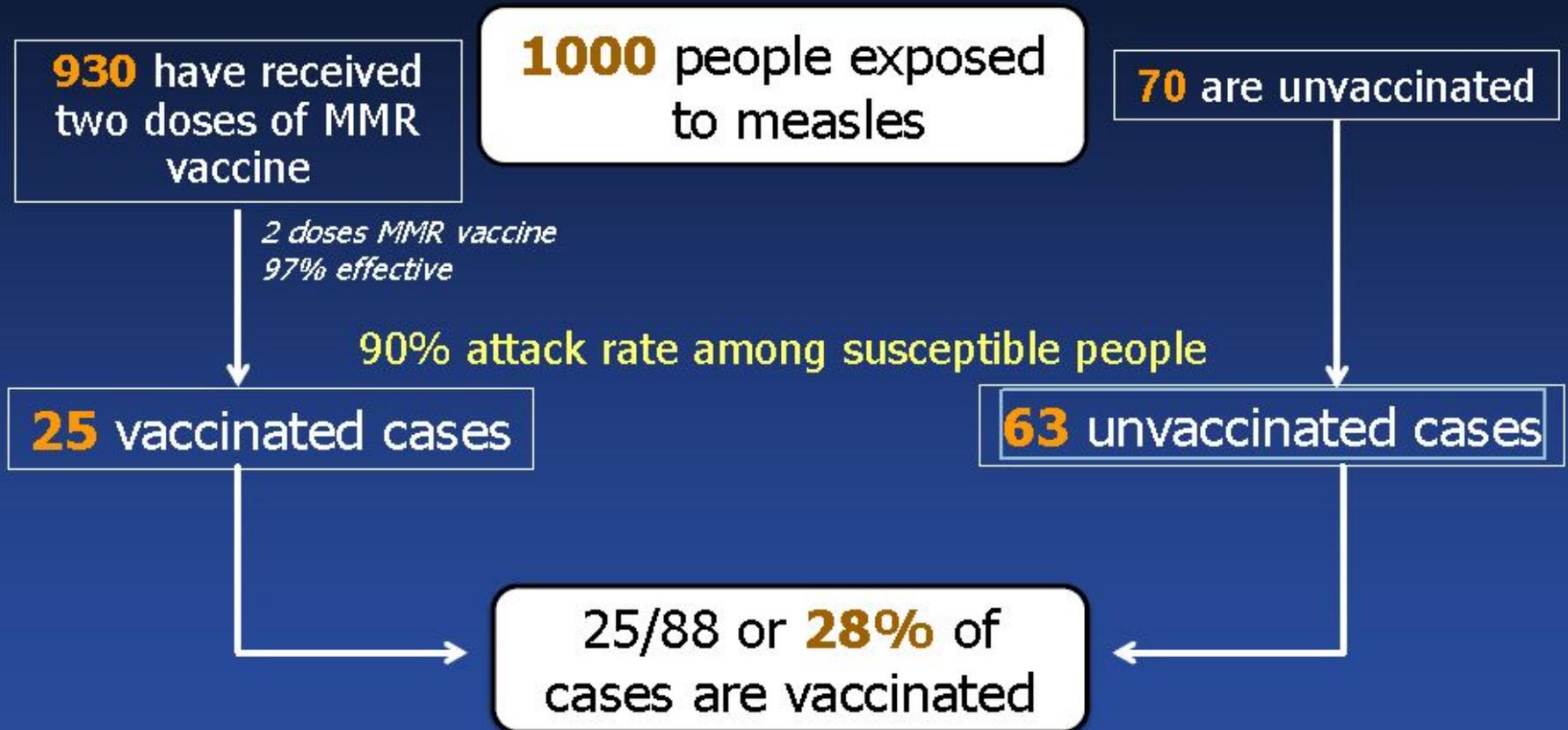
- Measles disease in Orange County was weighted toward unvaccinated cases
- Measles transmission was rare due to high immunization rates in the community
- Healthcare providers who care for measles patients are at particular risk of disease

California Measles Case Hospitalization Costs, 2009-2013, n=21*

- Total charges
 - Mean: \$26,344.95
 - Median: \$21,766
 - Range: \$5,207 – \$68,722
- Length of stay:
 - Mean: 2.77 days
 - Median: 3 days
 - Range: 1 – 7 days
- Age:
 - Mean = 22 years
 - Median: 18 years
 - Range: 0 (9 months) – 67 years
- Other diagnoses and complications:
 - Pneumonia: 3
 - Dehydration: 7
 - Septicemia: 1
 - Bacterial infection: 2
 - Anemia: 2
 - Otitis media: 1
 - Urinary tract infection: 1
- Procedures:
 - Intubated: 0
 - Blood transfusion: 0
 - Central line insertion: 0

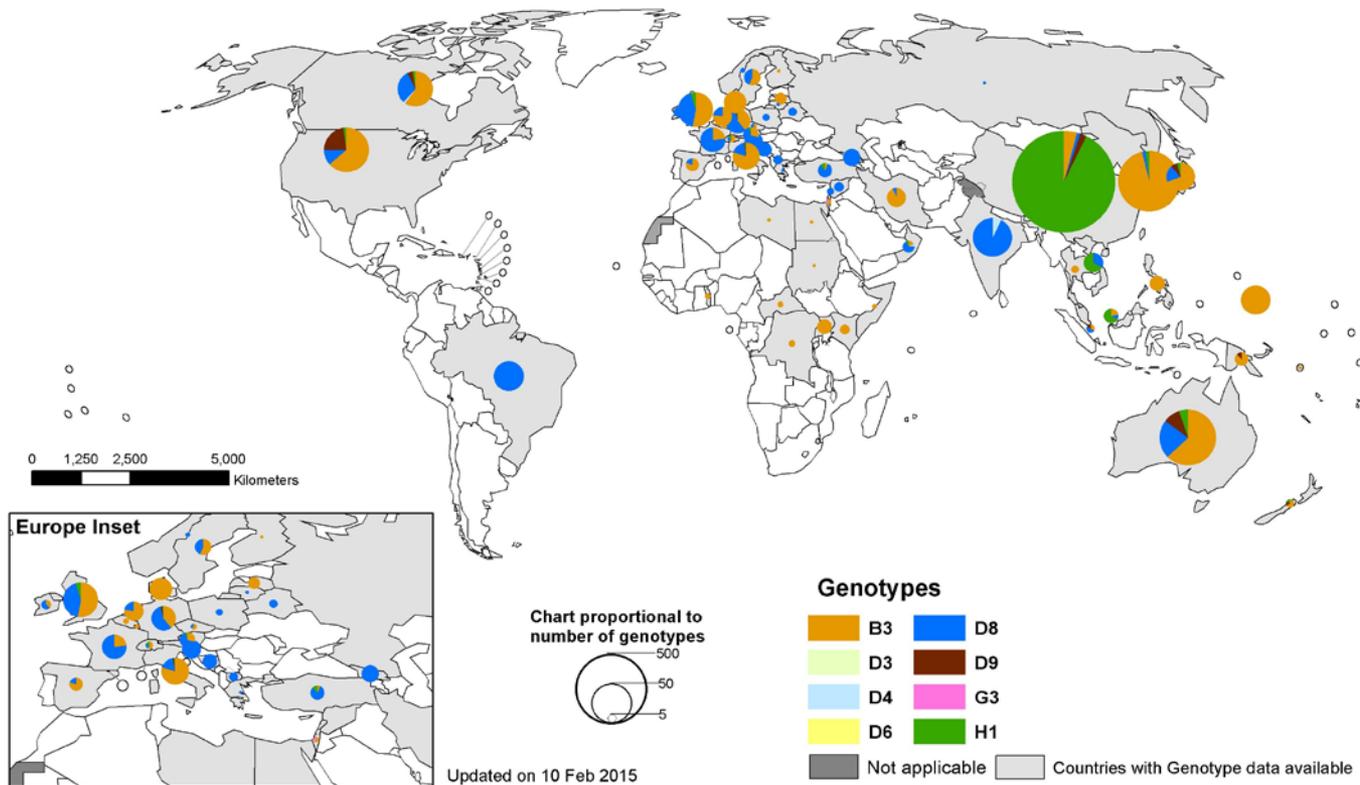
*No cost data on 1 Kaiser patient

Why do vaccinated people become infected with measles?



Distribution of Measles Genotypes, 2014

Distribution of measles genotypes, 2014



NICU Measles Exposure

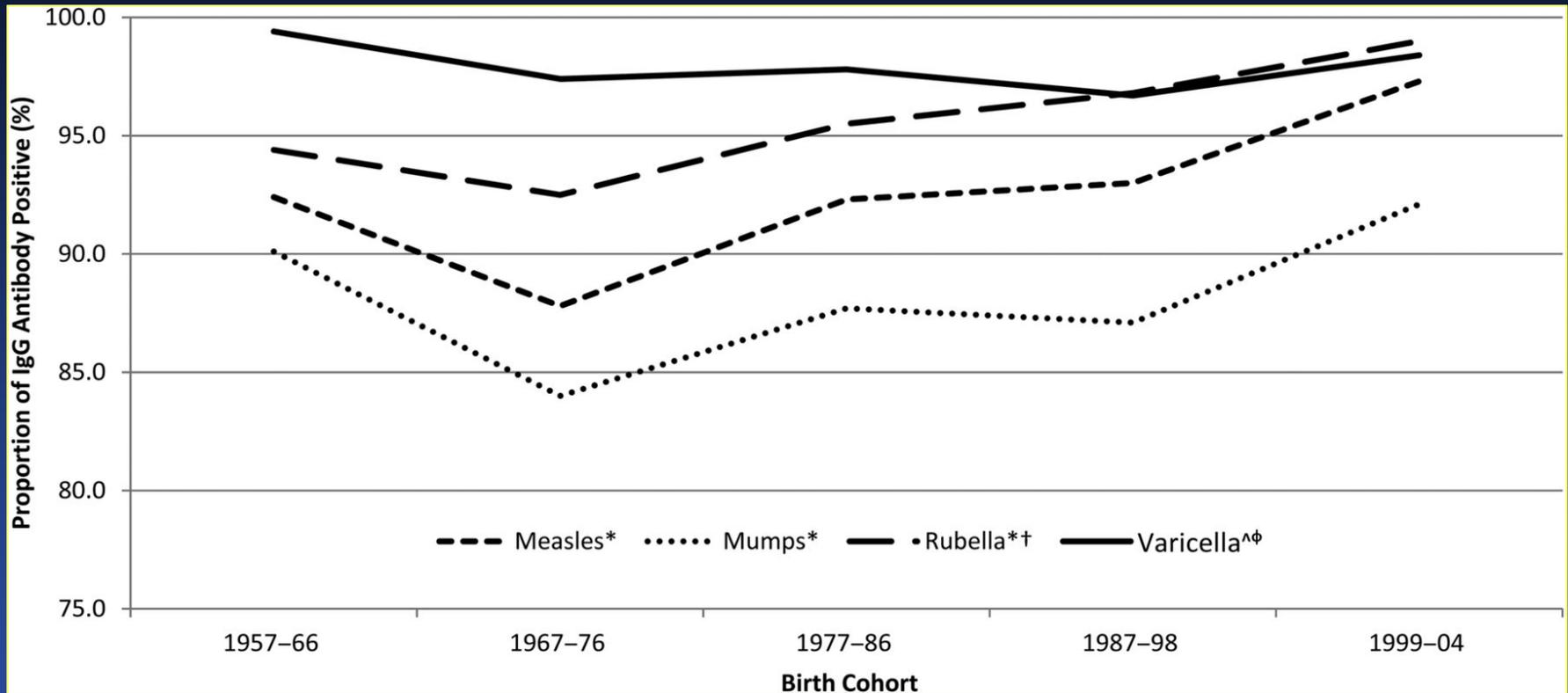
- An adult case who was linked to the measles outbreak visited multiple wards in a hospital, including an NICU, while infectious with measles
- A large contact investigation was initiated involving:
 - 98 neonates (44 of whom were exposed in the NICU); 70 neonates received IGIM post-exposure prophylaxis (PEP)
 - 14 pregnant women, 4 of whom received IGIV PEP
 - 237 hospital employees, 8 of whom were not immune to measles and were furloughed from work through the incubation period
- Discussions about what constituted an exposure in this setting and which infants were susceptible

Measles NICU Exposure: Recommendations

- Active monitoring of all neonates
- Biweekly screening of infants with high risk exposures to the case by measles PCR
- Cohorting and isolation of exposed neonates
- Log and symptom check for all visitors to NICU and labor and delivery wards
- Monitoring and symptom checks for all staff who were potentially exposed and continuing to work; work exclusion for any HCP not able to document presumed immunity to measles (either 2 MMR or IgG+)

***No transmission occurred**

Seroprevalence of measles, mumps, rubella (MMR) and varicella antibodies by birth cohorts: National Health and Nutrition Examination Survey, 2009–2010*



*For MMR: $P < .001$ for the test for linear trend from the 1967–1976 birth cohort to the 1999–2004 birth cohort; Estimate for rubella seroprevalence for birth cohort 1999–2004 may be unstable. Emmaculate J. Lebo et al. Open Forum Infect Dis. 2015.

Age (years)	Total	Incidence per 100,000 Population*	Percent
<1	14	2.67	11%
1-4	21	1.05	16%
5-19	24	0.31	18%
20-29	30	0.54	23%
30-39	21	0.40	16%
40-49	10	0.19	8%
50-59	9	0.18	7%
60-69	1	0.03	1%
70+	1	0.03	1%

* Population denominator data from the Department of Finance have been standardized with 2010 Census Data